In the Claims

The following is an amendment to and a complete listing of the claims which replaces all prior listings of claims in this application. Please note that this listing reflects the original claim numbers, which may have since been changed by the Examiner.

1. - 105. (Cancelled)

106. (Currently amended) A method for producing an initial velocity field estimate for a control plane from seismic data associated with said control plane and comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and the control plane having an edge intersecting a plurality of the CMP locations, the method comprising:

a) producing a starting velocity field estimate from an initial range of velocity values and ~~an initial range of velocity values and~~ an initial range of time values;

b) producing a migrated starting velocity field from said

starting velocity field estimate and said seismic data;

c) producing pre-stack imaged gathers by performing a 2-dimensional pre-stack imaging process on said seismic data;

d) producing normal moveout gathers in response to said migrated starting velocity field, including performing a normal moveout operation on said pre-stack imaged gathers;

e) adjusting said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field to produce a plurality of time-velocity values acting as said initial velocity field and said initial velocity field being stored in a computer readable medium.

107. (Original) The method of claim 106 wherein producing said starting velocity field estimate comprises defining a range of velocity values, defining one or more ranges of time values and associating each velocity value of said range of velocity values with one or more corresponding ranges of time values.

108. (Original) The method of claim 107 further comprising, for each of a plurality of CMP gathers, defining a window in which a selected CMP location associated with said each CMP gather is centered.

109. (Original) The method of claim 108 further comprising producing a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window.

110. (Original) The method of claim 109 further comprising producing a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights.

111. (Original) The method of claim 110 further comprising producing smoothing weights for each velocity value of said range of velocity values and each time value of said one or more corresponding ranges of time values in response to respective products of total semblance and reciprocal velocity gradient

associated with said each time value and said each velocity value.

112. (Original) The method of claim 111 further comprising producing a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

113. (Original) The method of claim 112 further comprising producing laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

114. (Original) The method of claim 106 wherein producing said migrated starting velocity field comprises, for said each of the CMP locations, producing a normal moveout gather in response to said starting velocity field estimate and seismic data associated with said each CMP locations.

115. (Original) The method of claim 114 further comprising producing a CMP stack for said each CMP location in response to a corresponding said normal moveout gather.

116. (Original) The method of claim 115 further comprising producing a simulated CMP gather for said each CMP location in response to a corresponding said CMP stack and a corresponding time-velocity profile associated with said each CMP location.

117. (Original) The method of claim 116 further comprising producing pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations.

118. (Original) The method of claim 117 further comprising producing normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and said starting velocity field estimate.

119. (Original) The method of claim 118 wherein producing said migrated velocity field comprises producing said migrated velocity field in response to said normal moveout pre-stack imaged simulated gathers and said starting velocity field estimate.

120. (Original) The method of claim 119 wherein producing said migrated velocity field comprises, for said each CMP

location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

121. (Original) The method of claim 120 wherein finding said slope of said curve comprises producing slant stack values for a plurality of time(tau)-slope pairs.

122. (Original) The method of claim 121 further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

123. (Original) The method of claim 122 further comprising producing a first temporary time-velocity representation in response to said starting velocity field estimate and a plurality of said best slope values.

124. (Original) The method of claim 123 wherein producing said first temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said starting velocity field estimate according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_{\tau} + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_{τ} is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

125. (Original) The method of claim 124 further comprising conditioning said plurality of best slope values to produce conditioned best slope values and producing an adjusted time-velocity representation in response to said temporary time-

velocity representation and said conditioned best slope values according to said relation.

126. (Original) The method of claim 125 wherein adjusting said migrated starting velocity field comprises, for each of the CMP locations and for each of said common seismic events, finding a slope of a curve approximating said trend, relative to offset, in said time values, associated with said each common seismic event.

127. (Original) The method of claim 126 wherein finding said slope of said curve-comprises producing slant stack values for a plurality of time(tau)-slope pairs.

128. (Original) The method of claim 127 further comprising, for said each CMP location, producing for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

129. (Original) The method of claim 128 further comprising producing a second temporary time-velocity representation in response to said migrated starting velocity field and a plurality of said best slope values.

130. (Original) The method of claim 129 wherein producing said second temporary time-velocity representation comprises adjusting each velocity value at a given time t of a corresponding time-velocity representation of said migrated starting velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

131. (Original) The method of claim 130 further comprising conditioning said plurality of best slope values to produce conditioned best slope values and adjusting said migrated starting velocity field in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

132. (Original) A computer readable medium encoded with codes for directing a processor circuit to carry out the method of claim 106.

133. (Original) A computer readable signal encoded with codes for directing a processor circuit to carry out the method of claim 106.

134. (Original) An apparatus for producing an initial velocity field estimate for a control plane from seismic data associated with said control plane and comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and the control

plane having an edge intersecting a plurality of the CMP locations, the apparatus comprising:

a) means for producing a starting velocity field estimate from an initial range of velocity values and an initial range of time values;

b) means for producing a migrated starting velocity field from said starting velocity field estimate and said seismic data;

c) means for producing pre-stack imaged gathers by performing a 2-dimensional pre-stack imaging process on said seismic data;

d) means for producing normal moveout gathers in response to said migrated starting velocity field, including performing a normal moveout operation on said pre-stack imaged gathers;

e) means for adjusting said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field to produce a

plurality of time-velocity values for each of the CMP locations, said plurality of said time-velocity values acting as said initial velocity field.

135. (Original) An apparatus for producing an initial velocity field estimate for a control plane from seismic data associated with said control plane and comprising time-amplitude representations associated with source-receiver locations spaced apart by an offset distance and having a midpoint therebetween, the seismic data being arranged into common midpoint (CMP) gathers associated with respective CMP locations and the control plane having an edge intersecting a plurality of the CMP locations, the apparatus comprising:

a) a component configured to produce a starting velocity field estimate from an initial range of velocity values and an initial range of time values;

b) a component configured to produce a migrated starting velocity field from said starting velocity field estimate and said seismic data;

c) a component configured to produce pre-stack imaged gathers by performing a 2-dimensional pre-stack imaging process on said seismic data;

d) a component configured to produce normal moveout gathers in response to said migrated starting velocity field, including performing a normal moveout operation on said pre-stack imaged gathers;

e) a component configured to adjust said migrated starting velocity field in response to said normal moveout gathers and said migrated starting velocity field to produce a plurality of time-velocity values for each of the CMP locations, said plurality of said time-velocity values acting as said initial velocity field.

136. (Original) The apparatus of claim 135 wherein said component configured to produce said starting velocity field estimate comprises a processor circuit configured to define a range of velocity values, define one or more ranges of time values and associate each velocity value of said range of velocity values with one or more corresponding ranges of time values.

137. (Original) The apparatus of claim 136 wherein said processor circuit is configured to, for each of a plurality of CMP gathers, define a window in which a selected CMP location associated with said each CMP gather is centered.

138. (Original) The apparatus of claim 137 wherein said processor circuit is configured to produce a semblance panel associated with said selected CMP location, in response to said range of velocity values and selected CMP gathers associated with CMP locations within said window.

139. (Original) The apparatus of claim 138 wherein said processor circuit is configured to produce a time-velocity profile associated with said selected CMP location in response to said semblance panel and a set of velocity stacking weights.

140. (Original) The apparatus of claim 139 wherein said processor circuit is configured to produce smoothing weights for each velocity value of said range of velocity values and each time value of said one or more corresponding ranges of time values in response to respective products of total semblance and

reciprocal velocity gradient associated with said each time value and said each velocity value.

141. (Original) The apparatus of claim 140 wherein said processor circuit is configured to produce a smooth time-velocity profile associated with said selected CMP location in response to said time-velocity profile and said smoothing weights.

142. (Original) The apparatus of claim 141 wherein said processor circuit is configured to produce laterally edited and laterally smoothed time-velocity profiles in response to a plurality of said smooth time-velocity profiles.

143. (Original) The apparatus of claim 135 wherein said component configured to produce said migrated starting velocity field comprises said processor and wherein said processor is configured to, for said each of the CMP location, produce a normal moveout gather in response to said starting velocity field estimate and seismic data associated with said each CMP location.

144. (Original) The apparatus of claim 143 wherein said processor circuit is configured to produce a CMP stack for said

each CMP location in response to a corresponding said normal moveout gather.

145. (Original) The apparatus of claim 144 wherein said processor circuit is configured to produce a simulated CMP gather for said each CMP location in response to a corresponding said CMP stack and a corresponding time-velocity profile associated with said each CMP location.

146. (Original) The apparatus of claim 145 wherein said processor circuit is configured to produce pre-stack imaged simulated gathers in response to a plurality of respective said simulated CMP gathers and respective said CMP locations.

147. (Original) The apparatus of claim 146 wherein said processor circuit is configured to produce normal moveout pre-stack imaged simulated gathers in response to said pre-stack imaged simulated gathers, said CMP locations and said starting velocity field estimate.

148. (Original) The apparatus of claim 147 wherein said processor circuit is configured to produce said migrated velocity field by producing said migrated velocity field in response to

said normal moveout pre-stack imaged simulated gathers and said starting velocity field estimate.

149. (Original) The apparatus of claim 148 wherein said processor circuit is configured to produce said migrated velocity field by, for said each CMP location and for each of said common seismic events, finding a slope of a curve approximating a trend, relative to offset, in said time values, associated with said each common seismic event.

150. (Original) The apparatus of claim 149 wherein said processor circuit is configured to find said slope of said curve by producing slant stack values for a plurality of time(tau)-slope pairs.

151. (Original) The apparatus of claim 150 wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

152. (Original) The apparatus of claim 151 wherein said processor circuit is configured to produce a first temporary

time-velocity representation in response to said starting velocity field estimate and a plurality of said best slope values.

153. (Original) The apparatus of claim 152 wherein said processor circuit is configured to produce said first temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of said starting velocity field estimate according to the relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

154. (Original) The apparatus of claim 153 wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and produce an adjusted time-velocity representation in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

155. (Original) The apparatus of claim 154 wherein said component configured to adjust said migrated starting velocity field comprises said processor circuit configured to, for each of the CMP locations and for each of said common seismic events, find a slope of a curve approximating said trend, relative to offset, in said time values, associated with said each common seismic event.

156. (Original) The apparatus of claim 155 wherein said processor circuit is configured to find said slope of said curve

by producing slant stack values for a plurality of time(tau)-slope pairs.

157. (Original) The apparatus of claim 156 wherein said processor circuit is configured to, for said each CMP location, produce for each time value of said time(tau)-slope pairs a best slope value in response to said time(tau)-slope pairs and said slant stack values.

158. (Original) The apparatus of claim 157 wherein said processor circuit is configured to produce a second temporary time-velocity representation in response to said migrated starting velocity field and a plurality of said best slope values.

159. (Original) The apparatus of claim 158 wherein said processor circuit is configured to produce said second temporary time-velocity representation by adjusting each velocity value at a given time t of a corresponding time-velocity representation of said migrated starting velocity field according to a relation:

$$V_{adj}(t) = \frac{1}{\sqrt{2\tau P_\tau + \frac{1}{V_{rep}^2}}}$$

where

$V_{adj}(t)$ is an adjusted velocity value associated with said given time t;

τ is a Tau value equal to said given time t;

P_τ is said best slope value at $\tau = t$; and

V_{rep} is said each velocity value at said given time t of said corresponding time-velocity representation.

160. (Original) The apparatus of claim 159 wherein said processor circuit is configured to condition said plurality of best slope values to produce conditioned best slope values and adjust said migrated starting velocity field in response to said temporary time-velocity representation and said conditioned best slope values according to said relation.

161. - 250. (Cancelled)